

Physical activity, physical fitness and cognitive function in adolescents

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Abstract

Introduction. Physical activity (PA) brings cognitive, mental and physical improvements in adolescents, benefiting physical fitness (PF), cognitive results and mental health. **Aim of Study.** The present study aimed to analyze and characterize the level of PA, PF and attention in adolescents. **Material and Methods.** A descriptive cross-sectional study was performed. Forty-three adolescents aged 16 to 18 years old (16.77 ± 0.61 years), where 53.5% ($n = 23$) were boys participated in the study. An international questionnaire was used to accessed PA and PF levels. The CAD-S Assessment Scale revised version was used to evaluate the level of attention. Standard statistical methods were used to calculate means, standard deviations, and chi-square test. **Results.** The results show a moderate level of PA practice in adolescents (60.5%) and a high level of PA in boys, whom have also a good perception of their PF level 53.5% ($p \leq 0.05$). In the attention capacity, high levels in the adolescents (79.1%) were observed. **Conclusions.** The adolescents have a good perception of their PA and PF levels, showing positive perception on cognitive function. The practice of PA daily at school and extracurricular contexts seems to be essential to obtain high levels of PF and attention, contributing to better academic performance and life quality.

KEYWORDS: concentration, attention, school, teens, exercise.

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Introduction

The regular practice of physical activity (PA) shows a positive association with the health of adolescents and can be a factor promoting change to an active lifestyle [3]. Moderate to vigorous intensity of PA is frequently suggested for health benefits [1, 28]. PA is characterized by any body movement produced through skeletal muscles that requires energy expenditure [3]. Literature suggests that individuals regularly practicing PA are less likely to have health problems [23], with research results confirming that it provides several health benefits e.g. to young people [2, 6, 20]. The relationship between PA practice and development of adolescents is of great interest, because it is an important phase to establish good healthy living habits, which can be further maintained during adulthood [17]. Previous researches also showed that PA and good physical fitness (PF) levels could support cognitive function and attention capacity both in children and adults [4, 13, 22].

In this sense, it seems to be important to develop motivating and effective programs, which value PA practice, producing benefits in PF, attention capacity, and even personal and social growth of adolescents [1, 25]. The PF defined as the ability to perform daily tasks with vigor and enough energy to enjoy the activities without fatigue [3], is considered a health factor improving the life quality of adolescents [9, 19]. High levels of PF in adolescents have been associated with more advantages, such as health-related outcomes regarding cognition and academic performance through psychological, physiological and learning methods [22]. Recently, PF has attracted great interest of teachers, parents and researchers, due to its positive influence on the cognitive function and academic performance [18, 24].

The cognitive function, especially attention, is a fundamental and determinant aspect when performing tasks or physical exercise for a long period of time, having a positive and significant relationship with vigorous PA and PF [29]. Attention can be described as a cognitive function defined by the behavioral and cognitive process of concentration in a task without the environment disturbances [29], but also involved in processes of activation and selection, distribution and maintenance of psychological activity [11]. A strong relationship between PA and the cognitive function has been reported, where better learning and development of attention skills in young people are accomplished [6, 10, 12, 14, 25, 27].

Although the relationship between PA and variables such as attention and PF is relatively well-known in adults [12], there is a lack of studies characterizing and analyzing this aspect in adolescents. Thus, due to the potential of PA to develop PF and attention, it was considered important to investigate the students' perception of their PA practice and PF levels, together with the importance of attention in daily tasks or in their academic performance. Therefore, the aim of the present investigation was to analyze and characterize the level of PA, PF and attention in adolescents. It was hypothesized that boys practice more PA, being more active and having a greater predisposition to higher PF than girls; it was also hypothesized that adolescents have a moderate level of attention, with high levels of attention in girls when compared with boys.

Material and Methods

Study design and settings

The study was carried out in a public secondary school in Beja, in two physical education classes, with data

collection taking place in January 2020. It was approved by the ethics committee of the Polytechnic Institute of Beja (protocol code No. 04/2019 and date of approval of 5th December 2019) and was following the latest version of the Declaration of Helsinki. Prior to the start of the study, all participants and their parents/guardians were informed about the study procedures. The written informed consent was obtained and signed by parents/guardians of all the participants. In the study an online questionnaire available through Google Forms was provided for the participants. The administration of the questionnaires was supervised by a researcher.

Participants

The sample consisted of 43 adolescents (aged 16.77 ± 0.61 years) from one secondary school cluster (Beja, Portugal), who were randomly assigned to the study. The average height of the entire sample was 1.67 ± 0.08 m. The inclusion criteria were: i) healthy young; and ii) young people without any type of injury/disorder (physical or mental). The exclusion criteria were: i) adolescents with physical disabilities, chronic or neurological diseases; ii) orthopedic limitation or clinical diagnosis of attention deficit hyperactivity disorders; and iii) regular extra-curricular PA.

Procedures

In this study both PA and PF were assessed by the PA and PF questionnaire, being characterized through questions related to PA and PF. The question concerning the PA levels was answered by providing the number of days PA was practiced in the last 7 days. The function of recoding into different variables was applied, where 0 and 1 day were converted to the value of 1, 2-4 to the value of 2, and 5-7 to the value of 3 respectively, and the value labels were changed to low, moderate, and high (Table 1). The extra-curricular PA practice was related, with answers ranging from "never practiced" to "practice" and "compete". They were also grouped through the function Recode into different variables: "I've never practiced sports" and "I've played sports, but right now I don't practice" assumed the value of 1 and "Yes, I play sports" and "Yes, I play sports and have already been in championships or competitions" assumed the value of 2. The value labels were set to "No" and "Yes" (Table 1).

Different dimensions of PF (fitness assessment, evaluation of cardiorespiratory condition, muscle strength assessment, speed and agility assessment and flexibility assessment) were recoded to the classification between "very bad" to "very good" assuming values from 0 to 4, having been

Table 1. Recoding physical activity

In the last 7-day period how many days was physical activity practiced (original)	In the last 7-day period how many days was physical activity practiced (recoded)
0 days	low
1 day	
2 days	moderate
3 days	
4 days	
5 days	high
6 days	
7 days	
Practice extra-curricular physical activity (original)	Practice extra-curricular physical activity (recoded)
I've never practiced sports	No
I've played sports, but right now I don't practice	
Yes, I play sports	Yes
Yes, I play sports and have already been in championships or competitions	

recoded into three different variables. Thus “very bad and bad” received the value of 1 (low), “acceptable” the value of 2 (moderate) and “good and very good” the value of 3 (high). Then the value labels of low, moderate and high were assumed.

In the last recoded variable, for the attention recoding, since the questionnaire used a 4-point Likert scale, the recoding considered the sum ranging from 0 to 27, having been recoded in three different variables, with 0-8 with the value of 1 (low), 9-17 with the value of 2 (moderate) and 18-27 with the value of 3 (high). As before, the value labels of low, moderate and high were assumed.

A Portuguese version [16] of the CAD-S Assessment Scale revised version [5] was administered on the sample, being an evaluation scale approved by the scientific community for Portugal and indicated for the evaluation and diagnosis of attention deficit hyperactivity disorder (ADHD). The scale of attention and concentration consisted of 9 items. The questionnaire used a 4-point Likert Scale, where 0 meant “It’s never true” and 3 “It’s always true”.

Statistical analysis

A cross-sectional descriptive study was performed. Statistical analysis was performed using the IBM SPSS® software, version 24.0 (Armonk, NY, USA). The sample description was made through a frequency analysis of all variables in the study. Standard statistical methods were used to calculate means and standard

deviations. To analyze the level of PA, PF and attention in adolescents and verify if there are differences between variables, crosstabs and chi-square test were performed. The normality of the data and the homogeneity were verified. The threshold of statistical significance was set at $p \leq 0.05$.

Results

The sociodemographic characteristics (i.e., gender and age) of the adolescents were recorded (Table 2). The general description of the sample according to the gender frequency analysis showed that there were more boys than girls and that most participants were 17 years old (Table 2).

Table 2. Sociodemographic characterization of the sample (n = 43)

Variable	n	(%)	
Gender	female	20	46.5
	male	23	53.5
Age	16	14	32.6
	17	25	58.1
	18	4	9.3

It was verified that most participants practice PA and that boys practice more PA (32.6%). A moderate practice of PA in the last 7 days (60.5%) was recorded where the

Table 3. Characterization of the level of physical activity

Variable		% (n)			$\bar{x} \pm SD$	p
		Female	Male	Total		
Physical activity	low	2.3% (1)	9.3% (4)	11.6% (5)	2.16 ± 0.615	0.169
	moderate	34.9% (15)	25.6% (11)	60.5% (26)		
	high	9.3% (4)	18.6% (8)	27.9% (12)		
	yes	18.6% (8)	32.6% (14)	51.2% (22)	1.51 ± 0.506	0.172
	no	27.9% (12)	20.9% (9)	48.8% (21)		

vast majority are female (34.9%). The response of PA in the last 7 days has a better average than the practice or no practice of PA and there is no significant relationship between PA and gender ($p \leq 0.05$) (Table 3).

A high level of PF in 53.5% of the adolescents was reported, being 39.5% males (Table 4). Considering the self-perception of PF variables, a high perception (46.5%) was revealed for cardiorespiratory fitness, in the case of muscle strength the participants perceived themselves to have moderate strength (60.5%), speed and agility were considered high (46.5%) as well as high

flexibility (41.8%) when compared with females. The highest average was reported in variables of PF, speed and agility, where the lowest average was observed in the flexibility variable. No significant relation was found between muscle strength and flexibility. However, PF ($p = 0.005$), cardiorespiratory fitness ($p = 0.003$), speed and agility variables ($p = 0.033$) showed significant differences between the genders (females and males).

Most of the sample (79.1%) demonstrated a high attention rate, where boys reported higher levels of

Table 4. Characterization of the level of physical fitness

Variable		% (n)			$\bar{x} \pm SD$	p
		Female	Male	Total		
Physical fitness	low	4.7% (2)	7.0% (3)	11.6% (5)	2.42 ± 0.698	0.005*
	moderate	27.9% (12)	7.0% (3)	34.9% (15)		
	high	14.0% (6)	39.5% (17)	53.5% (23)		
Cardiorespiratory fitness	low	25.6% (11)	7.0% (3)	32.6% (14)	2.14 ± 0.889	0.003*
	moderate	11.6% (5)	9.3% (4)	20.9% (9)		
	high	9.3% (4)	37.2% (16)	46.5% (20)		
Muscle strength	low	7.0% (3)	4.7% (2)	11.6% (5)	2.16 ± 0.615	0.206
	moderate	32.6% (14)	27.9% (12)	60.5% (26)		
	high	7.0% (3)	20.9% (9)	27.9% (12)		
Speed and agility	low	11.6% (5)	0.0% (0)	11.6% (5)	2.35 ± 0.686	0.033*
	moderate	18.6% (8)	23.3% (10)	41.9% (18)		
	high	16.3% (7)	30.2% (13)	46.5% (20)		
Flexibility	low	9.3% (4)	23.3% (10)	32.6% (14)	2.09 ± 0.868	0.202
	moderate	16.3% (7)	9.3% (4)	25.6% (11)		
	high	20.9% (9)	20.9% (9)	41.8% (18)		

* χ^2 significant values for $p < 0.05$; adjusted residuals $\geq |1.9|$ are considered significant (in bold)

Table 5. Characterization of the level of attention

Variable		% (n)			$\bar{x} \pm SD$	p
		Female	Male	Total		
Attention	low	0.0% (0)	0.0% (0)	0.0% (0)	1.21 \pm 0.412	0.889
	moderate	9.3% (4)	11.6% (5)	20.9% (9)		
	high	37.2% (16)	41.9% (18)	79.1% (34)		

attention than girls. However, no significant differences were observed between attention in the two gender (Table 5).

Discussion

The aim of the study was to analyze and characterize the level of PA, PF and attention in adolescents. The results suggested that the majority of adolescents practice PA (i.e., moderate PA is equivalent to 2-4 days/week). Boys practice more PA (i.e., high PA is equivalent to 5-7 days/week) than girls. The obtained results confirmed our first hypothesis. Previous studies [7, 15, 26] reported that boys showed higher levels of PA than girls, with the levels decreasing drastically during adolescence. On the other hand, Kristensen et al. [15] reported similar PA results for both genders. Moreover, Prieto-Benavides et al. [21] stated that higher levels of PA support higher levels of PF.

In the perception of the adolescents a high level of PF was reported, with boys showing a higher level than girls, who stated a moderate level (27.9%). With regard to PF, in the cardiorespiratory fitness variable a high level was reported mainly in boys. Sasayama and Adachi [26] showed high levels in both genders for cardiorespiratory fitness, which is contradictory to our results, where boys had higher levels than girls. However, Gonçalves and Silva [9] reported findings consistent with our results, indicating that girls had higher prevalence to low levels of cardiorespiratory fitness when compared with boys. Regarding muscle strength, a majority of the sample (more girls than boys) considered themselves to have a moderate level, although the results also show that there were more boys who considered themselves to have high muscle strength. Sasayama and Adachi [26] reported different results with boys and girls in terms of high levels of muscle strength. In the case of the speed and agility components, high levels were reported by a greater number of boys than girls (46.5%). Interestingly, Sasayama and Adachi [26] showed that both boys and girls had high levels of speed and agility. Finally, in flexibility as the last component of PF, the results were

similar to those obtained for the previous variables, and all adolescents showed high levels. Curiously, both girls and boys reported the high level.

Concerning the level of attention the adolescents self-reported high levels, where boys (41.9%) reported better results than girls (37.2%). The second hypothesis of the present study was not verified. Our results are consistent with the results presented by Hillman and Biggan [13], who reported a higher level of PF and a higher level of attention. This fact can be a stimulus for schools to improve levels of PF and promote active lifestyles [19]. So, the higher level of PA leads to a high level of PF, in turn providing high levels of attention [8].

This study has some limitations that should be considered: i) it is a cross-sectional study that does not establish a causal relationship; ii) the sample size does not allow generalizing the results. However, it is also pertinent to report the strengths. The present study highlighted a good perception of the adolescents for their levels of PF and attention, reporting positive effects on their cognitive function. These results of the present study emphasized the importance of PA for the adolescents' health, which provides benefits in physical education classes, but also supports adolescents to obtain better attention capacity, leading to better academic performance. It could be pertinent in future studies to include a large population sample and adolescents with chronic or neurologic diseases to increase the generalizability of the reported results.

Conclusions

The main findings of this study contributed to characterize the levels of PA, PF and attention in adolescents. Those showing that the practice of PA in the adolescents is between 2-4 days a week (moderate PA), indicated an influence of levels of PF and attention, being characterized as high levels. Adolescents reported a good perception of their PA and PF levels, showing positive effects on their cognitive function. Through these results, there is a positive relation between PA and variables such as attention and PF in adolescents. Moreover, the practice

of PA daily at school and in extracurricular contexts seems to be fundamental to obtain high levels of PF and attention, contributing to better academic performance and life quality.

Therefore, the current findings can be helpful for teachers and sport sciences professionals to innovate in physical education classes and to optimize exercise training programs, guaranteeing the motivation and practice for youth in those contexts.

Conflict of Interest

The authors declare no conflict of interest.

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